Mutant Algae Is Hydrogen Factory

By Sam Jaffe | Also by this reporter
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Researchers at the University of California at Berkeley have engineered a strain of pond scum that could, with further refinements, produce vast amounts of hydrogen through photosynthesis.

The work, led by plant physiologist Tasios Melis, is so far unpublished. But if it proves correct, it would mean a major breakthrough in using algae as an industrial factory, not only for hydrogen, but for a wide range of products, from biodiesel to cosmetics.

The new strain of algae, known as *C. reinhardtii*, has truncated chlorophyll antennae within the chloroplasts of the cells, which serves to increase the organism's energy efficiency. In addition, it makes the algae a lighter shade of green, which in turn allows more sunlight deeper into an algal culture and therefore allows more cells to photosynthesize.

"An increase in solar conversion efficiency to 10 percent ... is thought to be enough to make the mass culture of algae viable," says Juergen Polle, a former student of Melis' who now does research on algae at the City University of New York, Brooklyn.

Polle points out that Melis has probably already reached that 10 percent threshold. But further refinements are still required before *C. reinhardtii* farms would be efficient enough to produce the world's hydrogen, which is Melis' eventual goal.

Currently, the algae cells cycle between photosynthesis and hydrogen production because the hydrogenase enzyme which makes the hydrogen can't function in the presence of oxygen. Researchers hope to achieve that goal using genetic engineering to close up pores that oxygen seeps through.

Melis got involved in this research when he and Michael Seibert, a scientist at the National Renewable Energy Laboratory in Golden, Colorado, figured out how to get hydrogen out of green algae by restricting sulfur from their diet. The plant cells flicked a long-dormant genetic switch to produce hydrogen instead of carbon dioxide. But the quantities of hydrogen they produced were nowhere near enough to scale up the process commercially and profitably.

"When we discovered the sulfur switch, we increased hydrogen production by a factor of 100,000," says Seibert. "But to make it a commercial technology, we still had to increase the efficiency of the process by another factor of 100."

Melis' truncated antennae mutants are a big step in that direction. Now Seibert and others (including James Lee at Oak Ridge National Laboratories and J. Craig Venter at the Venter Institute in Rockville, Maryland) are trying to adjust the hydrogen-producing pathway so that it can produce hydrogen 100 percent of the time.

A bigger challenge, and one that's further down the road to solving, is improving the efficiency of the hydrogenase itself.

"Right now the electron chain that goes into the system should produce a lot more hydrogen than comes out, and we don't know what's causing the bottleneck," says Seibert. "More basic research is needed to better understand exactly what's happening in there." Seibert also points out that there are plenty of naturally occurring hydrogenases in microbes, most of which haven't been studied and some of which might be much more efficient than the one used by *C. reinhardtii*.

Whether or not scientists can find solutions for those two problems will have a lot to do with realizing the vision of a hydrogen-powered economy based on algae farms in desert areas.

But algae can do a lot more than produce hydrogen. They are already used widely in the cosmetics industry to produce key chemicals used in make-up and perfume. And pharmaceutical companies have long viewed algae as a potential way to produce drugs in a cheap and environmentally friendly manner.

Some algae are also viewed as an ideal source for biodiesel because they can produce oils at a much higher rate than other plants (which can then be converted into vehicle fuel without adding any carbon dioxide to the environment).

For all these applications, Melis' antenna-truncated algae should be a major breakthrough, allowing higher rates of production and thus making the end product more cheaply.